Biological Forum – An International Journal **14(4a): 472-475(2022)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Influence of Post-harvest Treatments on Shelf Life and Quality of Mango (*Mangifera indica* L.) cv. Alphonso

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(Received 21 September 2022, Accepted 17 November, 2022)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Mango fruits have a very limited shelf-life and fruits cannot be stored for a longer time at room temperature are particularly seasonally specific. Fruits were exposed to putrescine (1, 2 mM), hexanal (2, 3%) and carboxymethyl cellulose (1, 2%) for 15-minutes in an effort to enhance their shelf life. At 4-day intervals, ambient conditions were used to determine the physiological loss of weight (PLW), firmness, respiration rate, TSS and titratable acidity. In comparison to the control (13.56% and 167.69 mlCO_2/kg/h), fruits treated with PUT (2 mM) exhibited a lower PLW (5.35%) and respiration rate (145.57 mlCO_2/kg/h). Higher firmness (2.26 kg), a slower rate of TSS decrease and titratable acidity were all retained in fruits treated with 2 mM PUT. Control fruits soon lost firmness under storage and TSS duplication was more rapid. In conclusion, post-harvest dip treatment of 2 mM PUT dipped for 15-min effectively stored up to 23.54 days under ambient condition.

Keywords: Mango, Putrescine, Hexanal, Carboxymethyl cellulose, Postharvest dip andShelf life.

INTRODUCTION

The primary fruit crop produced in India is the mango (*Mangifera indica* L.), which has acquired fame around the world for its delectable flavour, exceptional nutritional benefits, enticing flavour, and appealing colour. But heavy postharvest losses mainly because of its climatric pattern of respiration, it can hardly be stored for a week under room condition (Jahurul *et al*., 2015). The post-harvest losses of mango account about 25-40 per cent at different stages from harvesting to the consumption (Tharanathan *et al*., 2006). We have found that there are several methods that may be employed to either reduce post-harvest losses or preserve fruit quality. These methods involve the use of substances like polyamine (putrescine), hexanal, carboxymethyl cellulose and other organic materials.

Aliphatic nitrogenous bases with a low molecular weight known as polyamines (PAs) have two or more amino groups and exhibit strong biological activity. They are found in both eukaryotic and prokaryotic cells. The majority of polyamines found in higher plants are in their free forms. The main polyamines in plants are putrescine (PUT), spermidine (SPD) and spermine (SPM), which are involved in the control of various physiological processes, such as flower development, embryogenesis, organogenesis, senescence, fruit maturation and development are all aspects of plant development. They are also engaged in biotic and abiotic stress responses (Chen *et al*., 2019).

Hexanal is a substance that develops spontaneously in plants after tissue damage through the lipoxygenase pathway. Exogenous administration of hexanal formulation has been shown to prolong fruit freshness by blocking the enzyme phospholipase-d, which is implicated in fruit deterioration (Anusuya *et al*., 2016).

A derivative of cellulose called carboxymethyl cellulose (CMC) has carboxymethyl groups attached to the hydroxyl group of glucopyranose.Although formally referred to as sodium carboxymethyl cellulose, the CMC is typically employed in the form of sodium salt. The CMC is thought to be water soluble and has great film-forming abilities. It helps preserve the distinctive flavour and taste of the treated goods since it is relatively permeable to respiration and transpiration (Ali *et al*., 2021).

MATERIAL AND METHODS

The investigation was carried out in the Department of Post-Harvest Technology laboratory at Kittur Rani Channamma College of Horticulture (University of Horticultural Sciences, Bagalkot) Arabhavi, Gokak, Belagavi, Karnataka between period of 2021 and 2022.

The fruits that were damaged, disfigured, bruised, punctured and infected were physically discarded. After that, field heat was removed by pre-cooling the healthy

fruits overnight. Fruits were then thoroughly rinsed in a 0.2 per cent sodium hypochlorite solution for five minutes to get rid of the dirt and microbial load that had accumulated on their surface. The fruits were dipped in aqueous solution of putrescine (1.0 and 2.0 mM), Hexanal (2.0 and 3.0%) and Carboxymethyl cellulose solution (1 and 2%) for 15 min and air-dried. Then, fruits were packed in ventilated corrugated fibre board (CFB) boxes of 12 fruits capacity which are commercially used by traders for export of mangoes. Paper lining was provided for cushioning and avoid fruits directly coming in contact with each other. In total, it simulated the commercial way of packing the mangoes. The observations on physiological loss in weight, respiration rate, firmness, shelf life, total soluble solids (TSS) and titratable acidity recorded at 4 days interval.

Physiological loss in weight (%). Mango fruits in each treatment were weighed to start storage, which was recorded as initial weight, and final weight was collected on the day of observation to assess the physiological loss of weight. The cumulative weight loss was then determined, and the percentage loss of weight (PLW) was stated in terms of fresh weight.

$$PLW = \frac{Initial - Final}{Initial} \times 100$$

Respiration rate (ml CO_2/kg/h). A CO_2 gas analyzer (Make: PBI Dansensor, Check Mate - II) was used to monitor the rate of respiration in a static manner. The fruit was weighed and contained for 10 minutes in a 1000 ml hermetically sealed container. Gas sample was taken from the container head space and injected into the CO_2 analyzer at the conclusion of the incubation time using a gas-tight syringe. The device read the change in CO_2 concentration in the head space and recorded the time. The respiration rate of the fruit was calculated using the following formula and expressed as ml CO_2/kg/h.

$$\text{Respiration rate (ml } CO_2\text{/kg/h)} = \frac{CO_2 \text{ concentration} \times \text{Volume of container (ml)}}{100 \times \text{weight of the tissue (kg)} \times \text{Time (h)}} \times 100$$

Shelf life (Days). Each fruit was carefully examined for any obvious signs of decomposition, and the end of the shelf life was determined when 20% of the fruits displayed signs of over ripening or spoiling.

TSS (ºB). Using a refractor, the total soluble solids were calculated. The peeled mango flesh was blended in a blender to create a homogenous sample. A few juice drops were placed on the prism of the refractometer after fully mixing the sample, and a direct reading was obtained by reading the scale in metres.

Titratable acidity (%). Using phenolphthalein indicator, a known volume of juice sample (10 ml) was obtained and titrated against standard NaOH. The end point was designated as the appearance of light pink colour. The number was given as a percentage of the juice's titratable acidity in terms of citric acid.

RESULTS AND DISCUSSION

Physiological loss in weight. The metabolic processes like transpiration and respiration are the major causes of weight loss. Along with the storage duration, the weight of mango fruits fell in both the control and treated fruits. The 2 mM PUT effectively decreased the physiological loss in weight. At the end of the storage period (12^{th} day) the PUT treated fruits exhibited minimum physiological loss in weight (5.35%) compared to untreated fruits (13. 56%). The increased weight loss in untreated fruits mainly attributed to acceleration of senescence, which is significantly suppressed by exogenous application of putrescine. As PUT forms a link with cell membranes and preserves cuticle layer waxes, the lower weight loss in PUT-treated mango fruits may be caused by stabilisation and consolidation of both cell integrity and the permeability of the tissues. This would delay the removal of epicuticular waxes, which are crucial for water exchange through the skin. Similar studies were done byMalik *et al*. (2006) in mango; Jawandha *et al*. (2012) in mango cv. Langra; Anju *et al.* (2014) in mango cv. Dashelari and Archana (2015) in banana cv. Grand Naine defend the results of the current study.

Respiration rate. In comparison to untreated fruits, the mango fruits treated with 2 mM PUT had the lowest respiration rate. Putrescine's antisenescence properties, the inhibition of ethylene synthesis or reduced rate of metabolism, and favourable water activity were mostly responsible for the lowered rate of respiration in putrescine-treated fruits (Barman *et al*., 2011; Champa *et al*., 2014). The results are in conformity with report of Barbang *et al*. (2002) in banana; Barman *et al*. (2011) in pomegranate; Malik *et al*. (2006) in mango.

Firmness. Firmness is a major quality attribute of fruits, normally fruits lose firmness due to tissue softening. Low quality and a higher incidence of mechanical damage during handling and shipping result from the loss of firmness during ripening. The 2 mM PUT effectively maintained the firmness of mango fruits and recorded maximum firmness compared to the control fruits. The impacts of polyamines may result from changes in the genes responsible for ethylene production, ethylene sensing, altered enzymes involved in cell walls, and polyamine conjugation. Valero *et al*. (2002) reported that It is believed that polyamine's ability to keep fruit firm is a result of its cross-linking to the carboxyl group of the pectic compounds in the cell wall, which causes rigidification. By inhibiting the action of cell wall-degrading enzymes such pectin estease, pectin methyl esterase, and poly galacturonase, the binds between polyamines and pectin also limit fruit softening during storage. These results are in line with the findings of Malik *et al*. (2006) in mango, Serrano *et al*. (2003); Perez *et al*. (2002) in plum.

Shelf life. Fruits treated with 2 mM PUT had the longest shelf life (23.54), whereas untreated fruits had the shortest shelf life (12.82). Mango fruits treated with polyamines had their shelf life increased by using slow ripening. With the exogenous administration of putrescine, the mango shelf life was increased without

affecting the fruit's organoleptic features by postponing fruit softening, lowering weight loss, lowering respiration rate, postponing colour development, and postponing the ripening process. Because of their anti-ethylene properties, the PAs function as amines that extend the shelf life of fruits by influencing a variety of physiological processes that take place during storage. Exogenous polyamine administration frequently slows or stops the onset of senescence. Many fruits' shelf lives have reportedly been extended by the polyamines as reported by Jawandha *et al*. (2012) in mango cv. Langra: Malik *et al*. (2006) in mango, Razzaq *et al*. (2014) in mango cv. Samar Bahisht Chaunsa.

TSS. The TSS increased along with the storage period. The maximum TSS was observed in untreated fruits, while the 2 mM PUT treated fruits had minimum TSS. Total soluble solids levels in fruits typically rise as they ripen. The primary indicator of fruit maturity or ripeness might be its soluble solids content. Increased water flow and the conversion of starch into soluble sugar during storage may have contributed to the fruits' increased TSS.

Table 1: Effect of postharvest treatments on physiological loss in weight and respiration rate of mango cv. Alphonso stored under ambient conditions.

Treatments	Physiological loss in weight (%)					Respiration rate (ml CO_2/kg/h)				
	Days after storage					Days after storage				
	4	8	12	16	20	4	8	12	16	20
T_1 - 1.0 mM PUT for 15 minutes	1.27	2.61	7.09	9.22	13.59	67.86	122.65	154.25	161.24	121.83
T_2 - 2.0 mM PUT for 15 minutes	0.73	2.21	5.35	8.13	12.66	58.59	108.42	145.57	157.82	133.61
T_3 - 2.0 % Hexanal for 15 minutes	3.49	6.50	12.12	*	*	91.53	219.41	134.92	*	*
T_4 - 3.0 % Hexanal for 15 minutes	5.61	9.55	14.79	*	*	97.03	243.96	163.30	*	*
T_5 - CMC 1 % for 15 minutes	2.10	4.40	8.16	12.19	14.93	71.39	143.85	191.89	81.82	67.54
T_6 - CMC 2 % for 15 minutes	2.11	3.17	7.65	10.71	13.76	78.15	159.59	176.74	87.13	76.74
T_7 – Control	4.28	6.40	13.56	*	*	105.30	235.41	167.69	*	*
Mean	**2.80**	**4.83**	**9.10**	**10.06**	**13.73**	**81.41**	**176.18**	**162.05**	**80.00**	**61.68**
S.Em±	0.03	0.08	0.13	-	-	0.96	2.04	1.70	-	-
C.D @ 1%	0.12	0.33	0.54	-	-	4.05	8.59	7.15	-	-

PUT – Putrescine; CMC - Carboxy methyl cellulose

* - No observations were recorded as the fruits lost their keeping quality; Initial value of respiration rate was 41.72 ml CO_2/kg/h

Table 2: Effect of postharvest treatments on firmness and shelf life of mango cv. Alphonso stored under ambient conditions.

Treatments	Firmness (kg)					Shelf life
	Days after storage					
	4	8	12	16	20	Days
T_1 - 1.0 mM PUT for 15 minutes	3.06	2.75	2.36	2.13	1.77	22.16
T_2 - 2.0 mM PUT for 15 minutes	3.22	2.90	2.54	2.26	1.86	23.54
T_3 - 2.0 % Hexanal for 15 minutes	2.51	2.03	1.75	*	*	14.83
T_4 - 3.0 % Hexanal for 15 minutes	2.65	1.92	1.63	*	*	13.56
T_5 - CMC 1 % for 15 minutes	2.87	2.74	2.23	2.04	1.61	21.58
T_6 - CMC 2 % for 15 minutes	2.91	2.89	2.44	2.11	1.70	20.10
T_7 – Control	2.82	2.44	2.01	*	*	12.82
Mean	**2.86**	**2.52**	**2.21**	**2.13**	**1.73**	**18.37**
S.Em±	0.04	0.04	0.03	-	-	0.33
C.D @ 1%	0.19	0.17	0.14	-	-	1.39

PUT – Putrescine; CMC - Carboxy methyl cellulose; * - No observations were recorded as the fruits lost their keeping quality
Initial value of firmness of fruits was 3.55 kg

Table 3: Effect of postharvest treatments on total soluble solids and titratable acidity of mango cv. Alphonso stored under ambient conditions.

Treatments	TSS (^{0}B)					Titratable acidity (%)				
	Days after storage					Days after storage				
	4	8	12	16	20	4	8	12	16	20
T_1 - 1.0 mM PUT for 15 minutes	11.23	14.73	16.15	17.19	18.50	2.151	1.680	1.153	0.962	0.656
T_2 - 2.0 mM PUT for 15 minutes	10.47	12.94	15.23	16.83	18.22	2.156	1.776	1.388	1.134	0.834
T_3 - 2.0 % Hexanal for 15 minutes	13.11	15.68	18.14	*	*	1.987	1.467	0.971	*	*
T_4 - 3.0 % Hexanal for 15 minutes	13.87	16.10	17.68	*	*	1.873	1.368	0.884	*	*
T_5 - CMC 1 % for 15 minutes	11.92	13.41	17.04	18.11	17.31	1.973	1.576	1.087	0.820	0.514
T_6 - CMC 2 % for 15 minutes	12.64	14.03	16.82	18.07	17.15	2.179	1.637	1.134	0.892	0.578
T_7 – Control	13.34	15.18	18.34	*	*	1.737	1.518	0.832	*	*
Mean	**12.37**	**14.58**	**15.52**	**17.55**	**17.79**	**2.008**	**1.574**	**1.064**	**0.544**	**0.369**
S.Em±	0.15	1.04	0.31	-	-	0.033	0.016	0.017	-	-
C.D @ 1%	0.63	0.25	1.29	-	-	0.137	0.067	0.072	-	-

PUT – Putrescine; CMC - Carboxy methyl cellulose

* - No observations were recorded as the fruits lost their keeping quality; Initial value of TSS - 7.60^{0}B and titratable acidity - 2.580 per cent

These results are in accordance with findings by Mula *et al*. (2009); Serrano *et al*. (2003); Jawandha *et al*. (2012); Venu(2018); Bhat *et al*. (2014); Gavri *et al*. (2016) in mango.

Titratable acidity. The delayed increase in TSS and breakdown of titratable acidity concentration in mango fruits treated with 2.0 mM PUT may be caused by the slower conversion of starch to sugar, the reduction in ethylene production, and finally the delay of ripening. The putrescine treatments, according the findings, demonstrated a considerably smaller drop in titratable acidity content after storage than the control treatment. In the current investigation, it appears that putrescine treatments had a considerable impact on respiration, which might cause respiration to slow down or stop altogether while maintaining titratable acidity levels. Comparable observations were recorded by Mula *et al*. (2009); Serrano *et al*. (2003); Jawandha *et al*. (2012); Venu (2018); Bhat *et al*. (2014) in mango.

CONCLUSION

Putrescine (PUT 2.0 mM) maintained the fruit firmness, delayed the physiological loss in weight, respiration rate and delayed changes in TSS and titratable acidity of mango fruit, hence the PUT can be effectively used to maintain the postharvest quality and to improve the storage life of mango fruits up to 23.54 days in ambient condition.

FUTURE SCOPE

The combination effect of retention of stalk length followed by post-harvest treatment with putrescine in mango on enhancement of shelf life in mango may be studied. The concentration of hexanal needs to be tried at levels lower than 2 per cent to reduce its possible toxic effect on fruits observed in the present study. The concentration of carboxymethyl cellulose needs to be tried at levels lower than 1 per cent to reduce its possible thick film forming effect on fruits as observed in the present study.

Acknowledgment. The Chairman, members of the advisory committee, and employees of the Department of Post Harvest Technology, KRC College of Horticulture, Arabhavi, have made me feel honoured and have earned my sincere gratitude and debt.

Conflict of Interest. None.

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How to cite this article: Vishwanath, Laxman Kukanoor, Kirankumar Gorabal, Shantappa Tirakannanavar, Praveen Jholgiker and Sumangala Koulagi (2022). Influence of Post-harvest Treatments on Shelf Life and Quality of Mango (*Mangifera indica* L.) cv. Alphonso. *Biological Forum – An International Journal*, *14*(4a): 472-475.